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Concentration and distribution of some chemicals from soil environment which irrigated by reuse wastewater: case study in Sana'a basin, Yemen

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ABSTRACT

The paper aims to investigate the impact of reuse of wastewater for irrigation purpose on chemical contains of the soil environmentof study area during the year 2015. Nowadaysbecause of the increase in population, the demand for water has increased rapidly, leading to water scarcity and this led to the trend towards the use of wastewater in agriculture to meet the shortfall in the required water for irrigation. The potential threat of heavy metals to human health has led to many studies on permissible levels of these elements in soil. The study conducted on five soil samples at a depth of 20 cm that analyzed for fifteen chemical parameters. During period 1; the results show the maximum values of B, Cu and Pb were 44.248, 27.929 and 5.999 (mg/kg) were from S3, S3, S1 samples respectively.During period 2 and 4; the maximum values of Ba, Cd, Ni, Sn, V, Zn and Cr were 171.965, 27.020, 72.305, 136.649, 72.737, 121.416 and 0,50 (mg/kg) were from S2, S2, S4, S3, S2, S3 and S5 samples respectively. During period3; the results show the maximum values of AS, Mo and Se 6.350, 43.090 and 0.850 (mg/kg) were from S1, S1, S5 samples respectively. The Maximum concentration of CN was during periods 2,3 and 4. Co was not detectable in all samples during four periodswhereas As, B, CN, Mo, Ni, Pb and Se were not detectable during periods 2 and 4. As, B, Ba, Zn, and CN were within the permissible limits during 4 periods while Pb, Se, Cd were within the permissible limits during p1 and p3 and Cu during p1, p2 and p3 and Ni during p1, p3 and p4. Cr was more than the permissible limits during 4 periods while Sn during P2 and P4 and during p1 form S1 and S3 and Mo during p1 and during P1 form S1 and S3 whereas V was more during p2 except S4 and during p3 from S1 and S3 and all the detectable samples duringp4.The studied parameters show more correlations 64 during p3 were less correlations 2 during p4. More correlations of studies were during p3 and less correlation were p4.

1. Introduction

During the last part of the 20th century, wastewater reuse has been considered a common procedure in many countries of the world and a great number of publications have recognized its benefits (Mujeriego and Sala, 1991; Levine and Asano, 2004 and Haruvy, 2006). The world faced with problems related to the management of wastewater. This is due to extensive industrialization, increasing population density and high-urbanized societies (EPA, 1993; McCasland *et al*., 2008). The effluents generated from domestic and industrial activities constitute the major sources of the natural water pollution load. This is a great burden in terms of wastewater management and can consequently lead to a point-source pollution problem, which not only increases treatment cost considerably, but also introduces a wide range of chemical pollutants and microbial contaminants to water sources (EPA, 1993, 1996; Eikelboom and Draaijer, 1999 and Amir *et al*., 2004).

In Yemen, the reuse of sewage effluents for irrigation is considered as animportant alternative water source in the new national water management strategy of the mountain cities (ACWUA, 2010; UN, 2012). Yemen is the least advanced country among Arab Countries in the sewage reuse and safety control as it has a predominantly rural setting, limited sewer connection, deteriorated WWTPs which do not meet national quality requirement and reuse patterns which are completely uncontrolled (ACWUA, 2010). Regardless of the quality of the effluent, farmers living near the disposal sites of sewage, especially in some of the large cities such as Sana'a, Taiz, Aden and Ibb are already practicing the reuse of non-treated or partially treated sewage effluents (Boydell *et al*., 2003; UN 2003). The situation in Sana'a city is extremely serious because more than 2 million people live in it, as a result of centralization and internal immigration. Accordingly, some areas of Sana'a basin experience water quality problem, especially the northern part of Sana'a city, i.e. Arhab and Bani Al-Harith areas around the wastewater treatment plant. Sana'a wastewater treatment plant (SWWTP) designed to operation by the Activated sludge- Extended aeration wastewater treatment system with a daily influent flow rate of 50.000 m3/d. Now the main problem is, Sana'a treatment plant operated overloaded therefore the effluent is partially treated or sometimes untreated (by-Pass), and the farmers used these effluent in agriculture. The activities of the population vary in the studied area from one district to another, and inside the same district according to educational, economic, and social factors. Agricultural fields cover about 40 % of the total area of the Sana'a basin (PACER, 2006). About 95 % of irrigation in the study area depends upon the sewage water produced from the Sana'a Wastewater Treatment Plant (SWWTP), with 5 % coming from groundwater (boreholes) that farmers use to directly irrigate the cultivated areas. The reason for this relates to the high cost of well water and the resultant decrease in economic income in comparison to irrigation with sewer water (PACER, 2006).

2. Aims of study

1. To determine the chemical parameters in the agricultural soil environment.
2. To evaluate the effect of wastewater from Sana'a wastewater treatment plant on the agricultural land of the region.

3. Material and method

Study area:

Sana'a Wastewater Treatment Plant (WWTP):

Sana'a Wastewater Treatment Plant (WWTP) is located in a sensitive area adjacent to the Sana'a International Airport with design capacity to treat 50,000 m3/day of sewage water, which comes from Sana'a .Sewage passage in Sana'a Basin starts at the outlet of the Sana'a City wastewater treatment plant at the northern edge of the Sana'a Basin. The passage runs across the basin for about 20 km until it reaches the main stream of Wadi Al-Khalid.Along the passage, there are three dams: Al-Mosyreka Dam, Al-Masham and Al-semna Dam. The passage runs across very critical geological features, including major faults, and encounters significant geological variation, including volcanic and limestone outcrops.

Sampling sites:

The study area is located in the Sana'a basin in western Yemen. It is characterized by several wadis and BeniHwat constitutes the principal river in the basin. The climate of the study area is arid, based on the ratio between average annual precipitation (P) and annual reference evaporation (Eo) (Arid: $0.03 < P/Eo < 0.25$). The temperature varies between 22 and 25 °C from November to January and between 30 and 31 °C from June to August. The maximum humidity reaches 50 % in April and November and the lowest value is 34 % in June. The highest wind speed reaches 9.7 km/h in June. March–May and July–August are the rainy periods, and the driest period is October–February. The average precipitation is 180 mm/year (Al-Musalli 2012; Alderwish 2010 and Hydrosult 2003).

Sampling:

The selected soil samples were collected from the sites every 3 months over 1 year during 2015 from January to December (period 1: from January to March, period 2: April–June, period 3: July–September and period 4: October–December). The five Soil samples at a depth of 20 cm were analyzed for fifteen parameters such as AS, B, Ba, Cd, Co, Cr, Cu , Li , Mo, Ni, Pb, Se, Sn, Sr, V, ZnandCN. The chemical parameters were measured according to the standard methods for the examination of water and wastewater (APHA, 1998 and USEPA 2007). The soil parameters were measured in a suspension of 1:10 soil to liquid (v/v), according to the procedure given in (ICARDA, 2003).

Arsenic (As)

As regarded as human carcinogen from extremely low levels of exposure, having no possible beneficial meta-bolic functions for humans (NAS/NRC, 1999). Its low-level exposure causes nausea and vomiting decreased production of RBCs and WBCs, abdominal pain and its long-term exposure causes darkening of skin and appearance of small corns on palm soles. Other affects includes- abnormal ECG, anorexia, fever, fluid loss, goiter, hair loss, headache, herpes, im-paired healing, jaundice, keratosis, kidney and liver damage, muscle spasms, pallor, peripheral neuritis, sore throat, weakness and interferes with the uptake of folic acid(NAS/NRC, 1999).The results during period 1;show that the lowest value was 0.269 mg/kg from S4 sample and the highest value was 3.623 mg/kg from S3sample (table 1) while the mean was 2.042 ±1.442 mg/kg. The study showed that there was a significant difference between the concentrationscontains of As of all soil samples ($P < 0.05$), however all samples were within the permissible limit (8 mg/kg) prescribed by WHO, 2006 (table 5). There was no correlations between As and other studied chemicals from selected soil samples (table 9).During period 2; the result shows that the ASwas not detectable in all samples during that period (table 2). Period 3; the result shows that the lowest value was 0.357 mg/kg from S4 sample and the highest value was 6.350 mg/kg from S1 sample (table 3) while the mean was 1.961 ± mg/kg 2.479. The study shows a significant difference between the concentrations contains of As of all soil samples ($P < 0.05$) however all the samples were less than the permissible limit (8 mg/kg) prescribed by WHO, 2006(table 7). There were positive correlations between CN and Mo (table 11). The results of the study shows that the As was not detectable in all samples during period4 (table 4).

Boron (B)

Clinical effects include irritability, seizures and gastrointestinal disturbances. There have also been reports of inflammation, congestion, exfoliation of the mucosa, exfoliative dermatitis, findings of cloudy swelling and granular degeneration of renal tubular cells and oedema. Clinical symptoms of boron toxicity have been reported within the dose range 100 to 55,500 mg depending on age/body weight. Inter-individual variability appears to behigh (WHO, 2010).During period 1; the result shows that the lowest value of B was 11.025 mg/kg from S4 sample and the highest value was 44.284 mg/kg from S3 sample (table 1) while the mean was 25.744 ± 13.255 mg/kg. The study showsa significant difference between the concentrations contains of B of all soil samples ($P < 0.05$) and all samples were more than the permissible limit (1.7 mg/kg) prescribed by WHO, 2006 (table 5). There were positive correlations between AS and Zn, Pb, Cu, Cr and Cd and showed highly positivecorrelation with Mo (table 9). During period 2; the B was not detectable in all samples (table 2). Period 3; the result shows that the lowest value was 6.505 mg/kg from S2 sample and the highest value was 37.948 mg/kg from S3 sample (table 3) while the mean was 21.485 ± mg/kg 14.316. The study shows a significant difference between the concentrations contains of B of all soil samples ($P < 0.05$) and all the samples were more than the permissible limit (1.7 mg/kg) prescribed by WHO, 2006(table 7). There were positive correlation between B and Ba and highly positive correlations with V, Pb, Ni,Cu, Cr and Cd (table 11).The results of the study show that the B was not detectable in all samples during period4 (table 4).

Barium (Ba)

Short term exposure can cause vomiting, abdominal cramps, diarrhea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, and muscle weakness (NAS/NRC, 1999). During period 1; the result shows that the lowest value was 44.814 mg/kg from S4 sample while the highest value was 86.032 mg/kg from S2 sample (table 1) with the mean of 65.768± 18.135 mg/kg. The study showed that there was a significant difference between the concentrations contains of Baof all soil samples ($P < 0.05$) howeverall samples were less than the permissible limit (302 mg/kg) prescribed by WHO, 2006 (table 5). There was no correlations between Ba and other studied chemicals of selected soil samples (table 9).During period 2; the result shows the lowest value was 31.697 mg/kg from S4 sample andthe higher value was 171.964 mg/kg from S2 sample and (table 2) while the mean was 114.676 ± 52.999 mg/kg. The study shows a significant difference between the concentrations contains of Ba of all soil samples ($P < 0.05$) howeverall the samples were less than the permissible limit (302 mg/kg) prescribed by WHO, 2006 (table 6). There were no correlations between Ba and other parameters studied (table 10). Period 3; the result shows that the lowest value was 12.694 mg/kg from S2 sample and the highest value was 128.300 mg/kg from S1 sample (table 3) while the mean was 55.836 ± mg/kg 51.165. The study shows a significant difference between the concentrations contains of Ba of all soil samples ($P < 0.05$) however all the samples were less than the permissible limit (302 mg/kg) prescribed by WHO, 2006 (table 7). There were positive correlations between Ba and B, Zn, Pb, Ni, Cu, Cr and Cd and negative correlation with Sn whereas highly positive correlations with V, Mo (table 11).Period 4; the result shows that the lowest value was 31.697 mg/kg from S4 sample and the highest value was 171.964 mg/kg from S2 sample (table 4) while the mean was 114.676± mg/kg 52.999. The study show a significant difference between the concentrations contains of Ba of all soil samples ($P < 0.05$) however all the samples were less than the permissible limit (302 mg/kg) prescribed by WHO, 2006 (table 8). There was highly positive correlationbetween Ba and Cr (table 12).

Cadmium

Cadmium is very toxic, its long-term exposure to lower levels leads to a buildup in the kidneys and possible kidney disease, lung damage, and fragile bones. Hypertension, arthritis, diabetes, anemia, cancer, cardiovascular disease, cirrhosis, reduced fertility, hypoglycemia, headaches, osteoporosis, kidney disease, and strokes are its some odd long-termresults (NAS/NRC, 1999). During period 1; the result shows that the lowest value was 0.313 mg/kg from S4 sample and the highest value was 1.063 mg/kg from S3 sample (table 1) while the mean was 0.573 ± 0.301 mg/kg. The study samples showed a significant difference between the concentrations contains of Cd ($P < 0.05$)howeverall samples were less than the permissible limit (4 mg/kg) prescribed by WHO, 2006 (table 5). There were positive correlations between Cd and Sn, Mo and Cuwhile showed highly positive correlation with Zn (table 9). During period 2; the result shows that Cd was not detectable in S2 and S5 samples the highest value of Cd was 27.019 mg/kg from S3 sample(table 2) while the mean was 11.769 ± 12.356 mg/kg. The study did not show a significant difference between the concentrations contains of Cd of all soil samples ($P > 0.05$) however all the detectable samples were more than the permissible limit (4 mg/kg) prescribed by WHO, 2006 (table 6). There were no correlations between Ba and other parameters studied (table 10).Period 3; the Cd was not detectable in S2 sample and the highest value was 0.715 mg/kg from S1 sample (table 3) while the mean was 0.293 ± 0.370mg/kg.The study shows a significant difference between the concentrations contains of Ba of all soil samples ($P < 0.05$) however all the samples were less than the permissible limit (4 mg/kg) prescribed by WHO, 2006 (table 7). There were positive correlations between Cd with Ba, Zn and Mo and negative correlation with Sn whereas highly positive correlations with B, V, Pb, Ni, Cu and Cr (table 11). Period 4; Cd was not detectable in S2 and S5 samples and whereas highest value was 27.019 mg/kg from S3 sample (table 4) while the mean was 11.769± 12.356mg/kg. The study did not show significant difference between the concentrations contains of Cd of all soil samples ($P > 0.05$) however all the detectable samples were more than the permissible limit (4 mg/kg) prescribed by WHO, 2006 (table 8). There was no correlation between Ba and other studied parameters (table 12).

Cobalt (Co)

The results of the study shows that the Co wasnot detectable in all samples during the four periods, 2015 (table 1,2,3 and 4).

Chromium

Chromium (VI) compounds are toxic and known human carcinogens, whereas chromium (III) is an essential element. Breathing high levels can cause irritation to the lining of the nose; nose ulcers; running nose; and breathing problems, such as asthma, cough, shortness of breath, or wheezing. Long-term exposure can cause damage to liver, kidney, circulatory and nerve disorders, as well as skin irritation (Kabata and Pendias, 1993). During period 1; the result shows that the lowest value was 3.717 mg/kg from S4 sample and the highest value was 36.806 mg/kg from S3 sample (table 1) while the mean was 21.662±11.961mg/kg. The study samples showed a significant difference between the concentrations contains of Cd ($P < 0.05$) and all samples were more than the permissible limit (0.4 mg/kg) prescribed by CSQG, 1991(table 5). There were positive correlations between Cr with Zn, Ni and Cu (table 9).During period 2; the result shows thatthe lowest value was 16.832 mg/kg from S4 sample and the highest value was 61.717 mg/kg from S2 sample (table 2) while the mean was 43.246± 17.015mg/kg. The study shows a significant difference between the concentrations contains of Cr of all soil samples ($P < 0.05$)however all the samples were more than the permissible limit (0.4 mg/kg) prescribed by CSQG, 1991(table 6). There were highly positive correlation between CrwithB (table 10).Period 3; the result shows that the lowest value was 7.412 mg/kg from S4 sample and the highest value was 32.701 mg/kg from S3 sample (table 3) while the mean was 18.514 ± 12.648mg/kg. The study shows a significant difference between the concentrations contains of Cr of all soil samples ($P < 0.05$) and all the samples were more than the permissible limit (0.4 mg/kg) prescribed by CSQG, 1991 (table 7). There were positive correlations between Cr with Ba, Zn and Mo and highly positive correlations with B, Cd, V, Pb, Ni and Cu (table 11). Period 4; the result shows that the lowest value was 16.832 mg/kg from S4 sample and the highest value was 61.717 mg/kg from S2 sample (table 4) while the mean was 43.246 ± 17.015 mg/kg. The study shows a significant difference between the concentrations contains of Cr of all soil samples ($P<0.05$) and all the samples were more than the permissible limit (0.4 mg/kg) prescribed by CSQG, 1991(table 8). There was no correlation between Cr and other parameters (table 12).

Copper (Cu)

Copper is an essential substance to human life, but its critical doses can cause anemia, acne, adrenal hyperactivity and insufficiency, allergies, hair loss, arthritis, autism, can-cer, depression, elevated cholesterol, depression, diabetes, dyslexia, failure to thrive, fatigue, fears, fractures of the bones, headaches, heart attacks, hyperactivity, hypertension, infections, inflammation, kidney and liver dysfunction, panic attacks, strokes, tooth decay and vitamin C and other vitamin deficiencies (Kabata and Pendias, 1993).Copper is one of the essential micronutrients and its adequate supply for growing plants should be ensured through artificial or organic fertilizers (Divrikli*et al*., 2006). During period 1; the result shows that the lowest value was 7.884 mg/kg from S4 sample and the highest value was 27.929 mg/kg from S3 sample (table 1) while the mean was 17.072 ± 8.098 mg/kg. The study samples did not show a significant difference between the concentrations contains of Cu ($P >0.05$) and all samples were less than the permissible limit (63 mg/kg) prescribed by CSQG, 1991(table 5). There were positive correlations between CuwithPb and Mo and highly positive correlation with Zn (table 9). The Cu was not detectable in all samples during periods 2 (table 2).Period 3; the result shows that the lowest value was 2.229 mg/kg from S2 sample and the highest value was 19.674 mg/kg from S3 sample (table 3) while the mean was 9.036 ± 7.992mg/kg. The study did not show significant difference between the concentrations contains of Cu of all soil samples ($P < 0.05$) and all the samples were less than the permissible limit (36 mg/kg) prescribed by CSQG, 1991 (table 7). There were positive correlations between Cu with Ba, Zn and V and highly positive correlations with B, Cd, Cr, Pb and Ni (table 11). The Cu was not detectable in all samples during periods (table 4).

Molybdenum (Mo)

Molybdenum ion poses a threat to the environment by greatly affecting terrestrial and aquatic life. The US Department and Health published the limit of maximum emission of the molybdenum ion as 40 ppm (US DHHS, 1978). During period 1; Mo was not detectable in S4 and S5 samples while the highest value was 1.602 mg/kg from S3 sample (table 1) and the mean was 0.594 ± 0.776 mg/kg. The study samples show a significant difference between the concentrations contains of Mo ($P <0.05$) howevertwo samples S1 and S3were more than the permissible limit (0.6 mg/kg) prescribed by WHO, 2006(table 5). There was positive correlation between MowithZn (table 9). The results of the study shows that the Mo was not detectable in all samples during period 2(table 2). Period 3; the result shows that the lowest value was 0.995 mg/kg from S4 sample and the highest value was 43.090 mg/kg from S1 sample (table 3) while the mean was 13.550 ± 18.750 mg/kg. The study shows a significant difference between the concentrations contains of Mo of all soil samples ($P < 0.05$) and all the samples were more than the permissible limit (0.6 mg/kg) prescribed by WHO, 2006 (table 7). There were positive correlations between Mo with As, Cd, Cr, Zn and V and negative correlation with Sn whereas highly positive correlation with Ba (table 11). The Mo was not detectable in all samples during periods 4 (table 4).

Nickel (Ni)

Nickel exceeding its critical level might bring about serious lung and kidney problems aside from gastrointestinal distress, pulmonary fibrosis and skin dermatitis (Borba *et al*., 2006).

During period 1; the result shows thatNi was not detectable in S4 sample while the highest value was 29.469 mg/kg from S1 sample (table 1) and the mean was 20.055 ± 12.505 mg/kg. The study samples show a significant difference between the concentrations contains of Ni ($P <0.05$) howeverall samples were less than the permissible limit (107 mg/kg) prescribed by WHO, 2006 (table 5). There was positive correlation between Ni with Pb (table 9).The results of the study show that the Ni was not detectable in all samples during period 2. There was no correlations between Ni and other studied chemicals of selected soil samples (table 10). Period 3; the result shows that the lowest value was 3.981 mg/kg from S2sample and the highest value was 30.076 mg/kg from S3 sample (table 3) while the mean was 15.004 ± 12.230 mg/kg. The study shows a significant difference between the concentrations contains of Ni of all soil samples ($P < 0.05$) however all the samples were less than the permissible limit (107 mg/kg) prescribed by WHO, 2006 (table 7). There were positive correlations between Ni with Zn and Ba whereashighly positive correlations with B, Cd, Cr, Cu, V and Pb (table 11).The Ni was detectable in one sample only during periods 4 which was 72.305mg/kg in S4 sample (table 4) while the mean was 14.461± 32.336 mg/kg. The study shows a significant difference between the concentrations contains of Ni of all soil samples ($P < 0.05$) however the detectable samples was less than the permissible limit (107 mg/kg) prescribed by WHO, 2006 (table 8). There were no correlations between Ni and other studied parameters (table 12).

Lead (Pb)

Lead can cause central nervous system damage. Lead can also damage the kidney, liver and reproductive system, basic cellular processes and brain functions. The toxic symptoms are anemia, insomnia, headache, dizziness, irritability, weakness of muscles, hallucination and renal damages (Naseem and Tahir, 2001). During period 1; the result shows that the lowest value was 1.852 mg/kg from S4 sample and the highest value was 5.999 mg/kg from S1 sample (table 1) while the mean was 4.098 ±1.793 mg/kg. The study samples show a significant difference between the concentrations contains of Pb (P <0.05) howeverall samples were less than the permissible limit (84 mg/kg) prescribed by WHO, 2006 (table 5). There were positive correlations between Pb with B, Cu and Zn (table 9). Pb was not detectable in all samples during three periods 2 (table 2). Period 3; the result shows that the lowest value was 0.354 mg/kg from S2 sample and the highest value was 4.795 mg/kg from S3 sample (table 3) while the mean was 2.417 ± 2.015 mg/kg. The study shows a significant difference between the concentrations contains of Ni of all soil samples (P < 0.05) however all the samples were less than the permissible limit (84 mg/kg) prescribed by WHO, 2006 (table 7). There were positive correlations between Pb with Ba and V whereas highly positive correlations with B, Cd, Cr, Cu and Ni (table 11). The Pb was not detectable in all samples during periods 4 (table 4).

Selenium (Se)

Selenium is toxic in large amounts, but trace amounts of it are necessary for cellular function. Short-term oral expo-sure to high concentrations can cause nausea, vomiting, and diarrhea. Major signs of selenosis are hair loss, nail brittle-ness, and neurological abnormalities. Brief exposures to high levels in air can result in respiratory tract irritation, bronchitis, difficulty breathing, and stomach pains. Longer- term exposure can cause respiratory irritation, bronchial spasms, and coughing(Kabata and Pendias, 1993). During period 1; the Se was detectable only in S1 sample (0.685 mg/kg) (table 1) while the mean was 0.137± 0.306 mg/kg. The study samples show a significant difference between the concentrations contains of Se (P <0.05) but the detected samplewas less than the permissible limit (6 mg/kg) prescribed by WHO, 2006 (table 5). There were no correlations between Se and other studied chemical elements (table 9). The results show that the Se was not detectable in all samples during three periods 2(table 2). Period 3; the Se was not detectable in S1, S3 and S4 sampleswhereas the highest value was 0.850 mg/kg from S5 sample (table 3) while the mean was 0.280 ± 0.398 mg/kg. The study shows a significant difference between the concentrations contains of Se of all soil samples (P < 0.05) however all the samples were less than the permissible limit (6 mg/kg) prescribed by WHO, 2006 (table 7). There were negative correlation between Se with CN (table 11).The Se was not detectable in all samples during periods 4 (table 4).

Tin (Sn)

The ingestion of relatively high concentrations of Sn is known to cause toxicity in various mammalian species. Toxicity symptoms range from fatigue, headaches, diarrhoea, vomiting, muscular weakness and paralyses, anaemia, excessive damage to the liver and kidneys, and a reduction in various levels of neurotransmitters in the brain (Gerren *et al.,* 1976; Graham *et al.,* 1976; WHO, 1980, 2004, 2005 and Snoeij *et al.,* 1987).During periods 1; the result shows that the Sn was not detectable in S4 sample and the highest value was 16.222 mg/kg from S3 sample (table 1) while the mean was 5.351±6.729 mg/kg. The study samples did not show a significant difference between the concentrations contains of Sn (P <0.05) howevertwo samples S2 and S3 were more than the permissible limit (5 mg/kg) prescribed by CSQG, 1991(table 5). There waspositivecorrelation between Sn and Cd (table 9). The results of the study shows that the Sn was not detectable in S1, S4 and S5 samples during period 2 and the highest value was 136.649 mg/kg from S3 sample (table 2) while the mean was 54.558± 74.707 mg/kg. The study did not show significant difference between the concentrations contains of Cr of all soil samples (P >0.05) and the detectable samples were more than the permissible limit (5 mg/kg) prescribed by CSQG, 1991 (table 6). There positive correlations between Sn and Cd (table 10). Period 3; Sn was not detectable in S1 sample whereas the highest value was 1.950 mg/kg from S5 sample (table 3) while the mean was 0.947 ± 0.783 mg/kg. The study shows a significant difference between the concentrations contains of Sn of all soil samples (P < 0.05) however all the samples were less than the permissible limit (5 mg/kg) prescribed by CSQG, 1991 (table 7). There were negative correlations between Se withBa, Cd, Mo,Zn and V(table 11).Period 4; Sn was not detectable in S1, S4 and S5 samples whereas the highest value was 136.649 mg/kg from S3 sample (table 4) while the mean was 54.558± 74.707mg/kg. The study did not show significant difference between the concentrations contains of Sn of all soil samples (P < 0.05) however all the samples were more than the permissible limit (5 mg/kg) prescribed by CSQG, 1991 (table 8). There were negative correlations between Sn with CN (table 12).

Vanadium (V)

A previous report (Heinemann *et al.,* 2000) showed that patients who had used albumin solutions containing high levels of V could suffer renal damage, especially those patients with existing impaired renal function. Some people in communities in northeastern Thailand are known to suffer health problems with regard to distal renal tubular acidosis. This was thought to have arisen from high environmentallevels of V in the soil as higher V levels were also found in these patients urine (Tosukhowong *et al.,*1999).During periods 1; V not detectable in all samples during that period (table 1). During period 2; the lowest value was 47.933 mg/kg from S1 sample and the higher value was 72.736 mg/kg from S2 sample and (table 2) while the mean was 47.522 ± 28.477mg/kg. The study did not show significant difference between the concentrations contains of V of all soil samples (P > 0.05) howeverall thedetectable samples were more than the permissible limit (47 mg/kg) prescribed by WHO, 2006 except S5 sample (table 6). There were negative correlations between V with Ni (table 10). Period 3; the result shows that the lowest value was 12.985 mg/kg from S2 sample and the highest value was 75.780 mg/kg from S1 sample (table 3) while the mean was 36.300 ± 31.266 mg/kg. The study did not show significant difference between the concentrations contains of V of all soil samples (P >0.05) however all the samples were less than the permissible limit (47 mg/kg) prescribed by WHO, 2006 except S1 and S3 samples (table 7). There was positive correlations between V with Zn, cu, Mo and Pb and negative correlation with Sn whereas highly positive correlations with B, Ba, Cd, Cr and Ni (table 11). Period 4; V not detectable in S5 Sample whereas the highest value was 72.736 mg/kg from S2 sample (table 4) while the mean was 47.522 ± 28.477 mg/kg. The study did not show significant difference between the concentrations contains of V of all soil samples (P > 0.05) howeverall detectable samples exceed the permissible limit (47 mg/kg) prescribed by WHO, 2006 (table 8). There was no correlation between V and other parameters (table 12).

Zinc (Zn)

Zinc is a trace element that is essential for human health. It is important for the physiological functions of living tissue and regulates many biochemical processes. However, too much zinc can cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anemia (Oyaro *et al.,* 2007). During periods 1; the result shows that the lowest value was 14.175 mg/kg from S4 sample and the highest value was 53.955 mg/kg from S3 sample (table 1) while the mean was 31.990± 15.937mg/kg. The study samples showed a significant difference between the concentrations contains of Cd (P < 0.05) however all samples were less than the permissible limit (200 mg/kg) prescribed by CSQG, 1991 (table 5). There were positive correlations between Zn with B, Cr, Mo and Pb and highly positive correlations with Cd and Cu (table 9).Period 2; the result shows that the lowest value was 77.898 mg/kg from S4 sample and the highest value was 121.416 mg/kg from S3 sample (table 2) while the mean was 101.836 ±15.735mg/kg. The study shows a significant difference between the concentrations contains of Zn of all soil samples (P < 0.05) however all the samples were less than the permissible limit (200 mg/kg) prescribed by CSQG, 1991 (table 6). There were no correlations between Zn and other parameters studied (table 10).Period 3; the result shows that the lowest value was 11.274 mg/kg from S4 sample and the highest value was 53.400 mg/kg from S1 sample (table 3) while the mean was 30.829± 19.253 mg/kg. The study showsa significant difference between the concentrations contains of Zn of all soil samples (P >0.05) however all the samples were less than the permissible limit (200 mg/kg) prescribed by CSQG, 1991 (table 7). There was positive correlations between Zn with Ba, Cd, Cr, Cu, Mo, Ni and V and negative correlation with Sn (table 11). Period 4; the result shows that the lowest value was 77.891 mg/kg from S4 sample whereas the highest value was 121.416 mg/kg from S3 sample (table 4) while the mean was 101.836 ± 15.753 mg/kg. The study shows a significant difference between the concentrations contains of Zn of all soil samples (P < 0.05) however all samples did not exceed the permissible limit (200 mg/kg) prescribed by CSQG, 1991 (table 8). There was no correlation between Zn and other parameters (table 12).

CN

Cyanide (CN) may occur in soils and water as a result of improper disposal ofCN - containing industrial wastes (Brooks, 1989; DeBell *et al.,* 1982; Galceran *et al.,*1990; Martin, 1992). In addition, naturally occurring CN exists in the environment as a result of microbial activity (Kunz, 1992). The detection and quantitative determination of CN in soils is integral to the proper assessment and ultimate remediation of contaminated media due to its potential impacts on public health and the environment (Pichtel *et al.,*, 1994).During periods 1; the result shows that CN was not detectable in S2 and S4 samples and the highest value was 0.100 mg/kg from S1 sample (table 1) while the mean was 0.021 ± 0.044 mg/kg. The study samples showed a significant difference between the concentrations contains of CN (P < 0.05) howeverall the samples were less than the permissible limit (0.9 mg/kg) prescribed by CSQG, 1991 (table 5). There were no correlations between CN and other parameters studied (table 9).Period 2; the result shows that the lowest value was 0.001 mg/kg from S3 sample and the highest value was 0.150 mg/kg from S5 sample (table 2) while the mean was 0.080 ± 0.056 mg/kg. The study shows a significant difference between the concentrations contains of Zn of all soil samples (P < 0.05) however all the samples were less than the permissible limit (0.9 mg/kg) prescribed by CSQG, 1991 (table 6). There were negative correlation between CN and Sn (table 10). Period 3; the result shows that the lowest value was 0.003 mg/kg from S5 sample and the highest value was 0.150 mg/kg from S4 sample (table 3) while the mean was 0.080 ± 0.063mg/kg. The study shows a significant difference between the concentrations contains of Zn of all soil samples (P >0.05) however all the samples were less than the permissible limit (0.9 mg/kg) prescribed by CSQG, 1991 (table 7). There was negative correlation with Se (table 11).Period 4; the result shows that the lowest value was 0.001 mg/kg from S3 sample whereas the highest value was 0.150 mg/kg from S5 sample (table 4) while the mean was 0.080 ± 0.056 mg/kg. The study shows a significant difference between the concentrations contains of CN of all soil samples (P < 0.05) however all samples did not exceed the permissible limit (0.9 mg/kg) prescribed by CSQG, 1991 (table 8). There was negative correlation between CN and Sn (table 12).

From the studied parameters,during the4 periods we gotfluctuations in the concentration of some chemical parameters. Some of them increasedhigher than the permissible limit during some periodswhile some others were lower during otherperiods. Hence, the irritation practice using of this wastewatermay create a health alarm to the all farmers in the region as well as the consumers of different food, similar finding with Sharma *et al.,* 2006; Chang *et al.,* 2002; Angelakis *et al.,*1999; Ansari,1993; Ghafoor, 2004 and Jolly *et al.,* 2013.Such studies are useful to estimate the level of metal contamination in agriculture soil by different anthropogenic activities, climate can also affect the soil content, and increases its content above the permissible limit,this finding is similar toLuo *et al.,* 2007 and Abbas Ullah Jan *et al.,* 2011. The accumulation of these chemicalsare due to the improper treatment of wastewater or by excessive useswhich discharged to the study region this finding, is similar toNWRA, 2007; Muchuwetiet *al.,* 2006; Becerra *et al.,* 2015; Kumar *et al.,* 2007; Janos *et al.,* 2010; Odoh and Kolawole, 2011; Ghafoor *et al.,* 1995 and Malla *et al.,* 2007.Treated waste for Sana'a wastewater treatment plantand from untreated wastewater surrounding flow together in the channel across the study region, this also accumulate the different chemicals to the area, similar finding with (kamal *et al.,*2016). Near the Sana'a wastewater treatment plant (SWWTP) farmers used 95% of wastewater to irrigate the cultivated area that may increase the soil quality that was reported by (Al-Sharabee, 2009).Some farmers in Yemen abstract wastewater directly from stabilization ponds to be used for the irrigation of a wide range of crops, especially the Qat thataffect the soil quality similar finding with (Al-Asbahi 2005; Haidar, 2005; ACWUA, 2010; Ministry of Agriculture and Irrigation, 2012 and UN, 2012).

4. Conclusion

Study focuses on the impact of wastewater on the selected soil samples located at Sana'a basin. According to estimated results, we can conclude that form 14 chemicals. Cr has the higher than the permissible limits during the 4 periods while otherfew parameters were quite higher than acceptable limitduring some periods or some samples such asSn, Mo and V. The studied parameters also show more correlations during p3 whereasthe less correlations were during 2 during p 4. Polluted soils can endanger human and animal health by various exposure routes. So we recommend that local people should not consume large quantities of any crops or vegetables that cultivated in this polluted samples and thereby avoid large accumulations of heavy metals in the body.Therefore, the authorities must make an urgent decision to change this contamination quickly through proper treatment of the wastewater that discharge through Sana'a basin.

Table 1: Concentration of chemical elements (mg/kg) in soil collected duringperiods 1.

Sl. No.	Elements	S1	S2	S3	S4	S5
1	AS	2.581	0.788	3.623	0.269	2.950
2	B	34.057	20.531	44.248	11.025	18.857
3	Ba	49.319	86.032	69.415	44.814	79.259
4	Cd	0.608	0.539	1.063	0.313	0.343
5	Co	ND	ND	ND	ND	ND
6	Cr	26.022	20.265	36.806	3.717	21.500
7	Cu	20.722	18.451	27.929	7.884	10.376
8	Mo	1.264	0.106	1.602	ND	ND
9	Ni	29.469	25.934	29.102	ND	15.773
10	Pb	5.999	4.263	5.631	1.852	2.743
11	Se	ND	0.685	ND	ND	ND
12	Sn	1.290	7.520	16.222	ND	1.725
13	V	ND	ND	ND	ND	ND
14	Zn	38.605	34.171	53.955	14.175	19.044
15	CN	0.100	ND	0.005	ND	0.001

ND= Not Detectable

Table 2: Concentration of chemical elements (mg/kg) in soil collected during periods 2.

Sl. No.	Elements	S1	S2	S3	S4	S5
1	AS	ND	ND	ND	ND	ND
2	B	ND	ND	ND	ND	ND
3	Ba	102.381	171.964	143.553	31.697	123.787
4	Cd	21.692	ND	27.019	10.133	ND
5	Co	ND	ND	ND	ND	ND
6	Cr	44.590	61.717	53.462	16.832	39.628
7	Cu	ND	ND	ND	ND	ND
8	Mo	ND	ND	ND	ND	ND
9	Ni	ND	ND	ND	72.305	ND
10	Pb	ND	ND	ND	ND	ND
11	Se	ND	ND	ND	ND	ND
12	Sn	000	136.143	136.649	ND	ND
13	V	47.933	72.736	65.881	51.055	ND
14	Zn	106.563	104.263	121.416	77.898	99.047
15	CN	0.125	0.025	0.100	0.150	0.003

ND= Not Detectable

Table 3: Concentration of chemical elements (mg/kg) in soil collected duringperiods 3.

Sl. No.	Elements	S1	S2	S3	S4	S5
1	AS	6.350	0.885	1.3639	0.357	0.850
2	B	35.620	6.505	37.948	12.511	14.840
3	Ba	128.300	12.694	91.238	21.058	25.890
4	Cd	0.680	ND	0.715	0.020	0.050
5	Co	ND	ND	ND	ND	ND
6	Cr	31.690	8.187	32.701	7.412	12.580
7	Cu	15.480	2.229	19.674	2.967	4.830
8	Mo	43.090	0.997	21.550	0.995	1.120
9	Ni	26.180	3.981	30.076	5.285	9.500
10	Pb	4.320	0.354	4.795	0.956	1.660
11	Se	ND	0.554	ND	ND	0.850
12	Sn	ND	1.201	0.324	1.264	1.950
13	V	75.780	12.985	64.785	13.853	14.100
14	Zn	53.400	26.538	48.374	11.274	14.560
15	CN	0.100	0.050	0.001	0.100	0.150

ND= Not Detectable

Table 4: Concentration of chemical elements (mg/kg) in soil collected during periods 4.

Sl. No.	Elements	S1	S2	S3	S4	S5
1	AS	ND	ND	ND	ND	ND
2	B	ND	ND	ND	ND	ND
3	Ba	102.381	171.964	143.553	31.697	123.787
4	Cd	21.692	ND	27.019	10.133	ND
5	Co	ND	ND	ND	ND	ND
6	Cr	44.590	61.717	53.462	16.832	39.628
7	Cu	ND	ND	ND	ND	ND
8	Mo	ND	ND	ND	ND	ND
9	Ni	ND	ND	ND	ND	ND
10	Pb	ND	ND	ND	ND	ND
11	Se	ND	ND	ND	ND	ND
12	Sn	ND	136.143	136.649	ND	ND
13	V	47.933	72.736	65.881	51.059	ND
14	Zn	106.563	104.263	121.416	77.891	99.047
15	CN	0.100	0.05	0.001	0.1	0.15

ND= Not Detectable

Table 5:Descriptive statistical analysis of studied chemicals from selected soil samples during period 1.

Sl.no	Elements	Minimum	Maximum	Mean ± S. D	standards	P value
1	AS	0.269	3.623	2.042 ± 1.442	8*	0.001
2	B	11.025	44.249	25.744 ± 13.255	1.7*	0.016
3	Ba	44.814	86.033	65.768 ± 18.135	302*	0.000
4	Cd	0.313	1.063	0.573 ± 0.301	4*	0.000
5	Co	ND	ND	ND	40**	0.016
6	Cr	3.717	36.806	21.662 ± 11.961	0.4**	0.000
7	Cu	7.884	27.929	17.072 ± 8.098	63**	0.988
8	Mo	ND	1.602	0.594 ± 0.776184	0.6*	0.000
9	Ni	ND	29.469	20.055 ± 12.505	107*	0.000
10	Pb	1.852	5.999	4.098 ± 1.793	84*	0.000
11	Se	ND	0.685	0.137 ± 0.306	6*	0.000
12	Sn	ND	16.222	5.351 ± 6.729	5**	0.840
13	V	ND	ND	ND	47*	----
14	Zn	14.175	53.956	31.990 ± 15.937	200**	.000
15	CN	ND	0.100	0.021 ± 0.044	0.9**	.000

*Limits WHO 2006, ** Canadian Soil Quality Guidelines 1991, SD= Standard Deviation, ND= Not Detectable, P < 0.05

Table 6:Descriptive statistical analysis of studied chemicals from selected soil samples during period 2.

Sl.no	Elements	Minimum	Maximum	Mean ± S. D.	standards	P value
1	AS	ND	ND	ND	8*	-----
2	B	ND	ND	ND	1.7*	-----
3	Ba	31.697	171.964	114.676 ± 52.999	302*	0.001
4	Cd	ND	27.019	11.769 ± 12.356	4*	0.232
5	Co	ND	ND	ND	40**	-----
6	Cr	16.832	61.717	43.246 ± 17.015	0.4**	0.005
7	Cu	ND	ND	ND	63**	-----
8	Mo	ND	ND	ND	0.6*	----
9	Ni	ND	72.305	14.461 ± 32.336	107*	0.003
10	Pb	ND	ND	ND	84*	----
11	Se	ND	ND	ND	6*	----
12	Sn	ND	136.649	54.558 ± 74.707	5**	0.220
13	V	ND	72.736	47.522 ± 28.477	47*	0.969
14	Zn	77.892	121.416	101.836 ± 15.753	200**	.0000
15	CN	0.001	0.150	0.080 ± 0.056	0.9**	0.000

*Limits WHO 2006, ** Canadian Soil Quality Guidelines 1991, SD= Standard Deviation, ND= Not Detectable, P < 0.05

Table 7: Descriptive statistical analysis of studied chemicals from selected soil samples during period 3.

Sl.no	Elements	Minimum	Maximum	Mean ± S. D.	standards	P value
1	AS	0.357	6.350	1.961 ± 2.479	8*	0.006
2	B	6.505	37.948	21.485 ± 14.316	1.7*	0.038
3	Ba	12.694	128.300	55.836 ± 51.165	302*	0.000
4	Cd	ND	0.716	0.293 ± 0.370	4*	0.000
5	Co	ND	ND	ND	40**	0.033
6	Cr	7.412	32.701	18.514 ± 12.648	0.4**	0.000
7	Cu	2.229	19.674	9.036 ± 7.992	63**	0.197
8	Mo	0.995	43.090	13.550 ± 18.750	0.6*	0.000
9	Ni	3.981	30.076	15.004 ± 12.230	107*	0.000

10	Pb	0.354	4.795	2.417 ± 2.015	84*	0.000
11	Se	ND	0.850	0.280 ± 0.398	6*	0.000
12	Sn	ND	1.950	0.947 ±0.783	5**	0.000
13	V	12.985	75.780	36.300 ± 31.266	47*	0.487
14	Zn	11.274	53.400	30.839 ± 19.253	200**	0.000
15	CN	0.003	0.150	0.080 ± 0.063	0.9**	0.000

*Limits WHO 2006, ** Canadian Soil Quality Guidelines 1991, SD= Standard Deviation, ND= Not Detectable, P < 0.05.

Table 8: Descriptive statistical analysis of studied chemicals from selected soil samples during period 4.

Sl.no	Elements	Minimum	Maximum	Mean ± S. D.	standards	P value
1	AS	ND	ND	ND	8*	-----
2	B	ND	ND	ND	1.7*	-----
3	Ba	31.697	171.964	114.676 ± 52.999	302*	0.001
4	Cd	ND	27.019	11.769 ±12.356	4*	0.232
5	Co	ND	ND	ND	40**	0.000
6	Cr	16.832	61.717	43.246 ± 17.015	0.4**	0.005
7	Cu	ND	ND	ND	63**	-----
8	Mo	ND	ND	ND	0.6*	----
9	Ni	ND	72.305	14.461 ± 32.336	107*	0.003
10	Pb	ND	ND	ND	84*	-----
11	Se	ND	ND	ND	6*	-----
12	Sn	ND	136.649	54.558 ± 74.707	5**	0.220
13	V	ND	72.736	47.522 ± 28.477	47*	0.969
14	Zn	77.892	121.416	101.836 ± 15.753	200**	0.000
15	CN	0.001	0.150	0.080 ± 0.056	0.9**	0.000

*Limits WHO 2006, ** Canadian Soil Quality Guidelines 1991, SD= Standard Deviation, ND= Not Detectable, P < 0.05.

Table 9: shows the Correlations between studied chemicals from selected soil samples during period 1.

	CN	Zn	V	Sn	Se	Pb	Ni	Mo	Cu	Cr	Co	Cd	Ba	B	AS
AS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
B	NS	.948*	NS	NS	NS	.901*	NS	.962*	.944*	.929*	NS	.936*	NS		
Ba	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Cd	NS	.965**	NS	.905*	NS	NS	NS	.882*	.956*	NS	NS				
Co	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS					
Cr	NS	.892*	NS	NS	NS	NS	.886*	NS	.889*						
Cu	NS	.999**	NS	NS	NS	.921*	NS	.881*							
Mo	NS	.885*	NS	NS	NS	NS	NS								
Ni	NS	NS	NS	NS	NS	.931*									
Pb	NS	.911*	NS	NS	NS										
Se	NS	NS	NS	NS											
Sn	NS	NS	NS												
V	NS	NS													
Zn	NS														
CN															

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed). NS= Non Significant

Table 10: shows the Correlations between studied chemicals from selected soil samples during period 2.

	CN	Zn	V	Sn	Se	Pb	Ni	Mo	Cu	Cr	Co	Cd	Ba	B	AS
AS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
B	NS	NS	NS	NS	NS	NS	NS	NS	NS	.969**	NS	NS	NS		
Ba	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Cd	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS				
Co	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS					
Cr	NS	NS	NS	NS	NS	NS	NS	NS	NS						
Cu	NS	NS	NS	NS	NS	NS	NS	NS							
Mo	NS	NS	NS	NS	NS	NS	NS								

	CN	Zn	V	Sn	Se	Pb
Ni	NS	NS	-.933*	NS	NS	NS
Pb	NS	NS	NS	NS	NS	
Se	NS	NS	NS	NS		
Sn	-.882*	NS	NS			
V	NS	NS				
Zn	NS					
CN						

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 11: shows the Correlations between studied chemicals from selected soil samples during period 3.

	CN	Zn	V	Sn	Se	Pb	Ni	Mo	Cu	Cr	Co	Cd	Ba	B	AS
AS	NS	NS	NS	NS	NS	NS	NS	.927*	NS	NS	NS	NS	NS	NS	
B	NS	NS	.963**	NS	NS	.997**	.992**	NS	.984**	.985**	NS	.985**	.943*		
Ba	NS	.916*	.988**	-.890*	NS	.932*	.928*	.984**	.901*	.953*	NS	.956*			
Cd	NS	.937*	.987**	-.892*	NS	.982**	.990**	.898*	.986**	.993**	NS				
Co	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS					
Cr	NS	.928*	.977**	NS	NS	.989**	.995**	.891*	.985**						
Cu	NS	.891*	.946*	NS	NS	.988**	.996**	NS							
Mo	NS	.906*	.957*	-.895*	NS	NS	NS								
Ni	NS	.896*	.960**	NS	NS	.996**									
Pb	NS	NS	.955*	NS	NS										
Se	-.952*	NS	NS	NS											
Sn	NS	-.927*	-.923*												
V	NS	.951*													
Zn	NS														
CN															

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 12: shows the Correlations between studied chemicals from selected soil samples during period 4.

	CN	Zn	V	Sn	Se	Pb	Ni	Mo	Cu	Cr	Co	Cd	Ba	B	AS
AS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
Ba	NS	NS	NS	NS	NS	NS	NS	NS	NS	.969**	NS	NS			
Cd	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS				
Co	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS					
Cr	NS	NS	NS	NS	NS	NS	NS	NS	NS						
Cu	NS	NS	NS	NS	NS	NS	NS	NS							
Mo	NS	NS	NS	NS	NS	NS	NS								
Ni	NS	NS	NS	NS	NS	NS									
Pb	NS	NS	NS	NS	NS										
Se	NS	NS	NS	NS											
Sn	-.882*	NS	NS												
V	NS	NS													
Zn	NS														
CN															

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

References

1. Abbas Ullah Jan, Mohammad Jamal Khan, Mohammad Tariqjan, Farhatullah, Naqib Ullah Khan, Mohammad Arif, Sajida Parveen, Shah Alam, 2011.The Effect of Using Waste Water on Tomato, *Pak J Bot*. 43, 1.
2. ACWUA, Arab Countries Water Utility Association, 2010. Wastewater reuse in Arab Countries, working group on wastewater reuse. Amman – Jordan.
3. Al-Asbahi Q. Y, 2005. Water resources information in Yemen, IWG-Environment, International work session on water statistics. Vienna, June 20–22, 2005.
4. Alderwish A., 2010. Induced recharge at new dam sites—Sana'a basin, Yemen. *Arab J Geosci.* 3(3):283–293
5. Al-Musalli., 2012. Wastewater reuse in irrigation through applying the IWRM concept
6. Al-Sharabee R., 2009 The effect of using wastewater on microbiological pollution for vegetable crops, MSc. Thesis, Faculty of Agriculture, Sana'a University, Yemen.
7. Amir H. M., Ali R. M., Farham K.,2004. Nitrogen removal from wastewater in a continuous flow sequencing batch reactor. *Pak. J. Biol. Sci*. 7(11): 1880-1883.
8. Angelakis A. N., Marecos Do Monte M. H. F., Bontoux L. Asano T., 1999.The status of wastewater reuse practice in the Mediterranean basin: need for guidelines. *Wat. Res*. Vol. 33, No. 10, pp. 2201±2217.
9. Ansari T. P., Kazi T. G. and Kazi G. H., 1993. Chemical compositions of vegetable grown on agricultural soil amended with sewage sludge of Mirpur Khas division. Proc. 5th National Chemistry Conference, Quaid-e-Azam University. Islamabad. Pp., 141-143.
10. APHA, 1998. Standard methods for the examination of waters and wastewaters.20th edition. New York. 1220.
11. Becerr, C., Lopes A. Vaz I. Silva E. Manaia C. Nunes O., 2015. Wastewater reuse in irrigation:A microbiological perspective on implications in soil fertility and human and environmental health. *Environ. Int*. 75, 117–135.
12. Borba C.E., Guirardello, R., Silva, E.A., Veit, M.T., Tavares, C.R.G., 2006. Removal of nickel(II) ions from aqueous solution by biosorption in a fixed bed column: experimental and theoretical breakthrough curves. *Biochem. Eng. J*. 30, 184e191.
13. Boydell R. A., Al-Hemyari A. A., Abdu K., Al-Suleihi S. T., Al Dubai K. Y., Iskandar M. M. & Whltford P. W., 2003 Project environmental impact assessment (Phase I). Report executive, summary and main report, Sana'a Basin Water Management Program, Yemen. Vol. 1, E707.
14. Brooks Steven J., 1989. Reclamation of the Timberline Heap Leach: Tooele County,Utah.
15. Chang A., Page A., Asano T., 2002. Developing human health-related chemical guidelines for reclaimed wastewater and sewage sludge applications in agriculture. Geneva: World Health Organization.
16. CSQG, Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health, 1991. Environment Canada, National Guidelines and Standards Office, 351 boul. St. Joseph, Gatineau, Quebec, K1A 0H3
17. DeBell R. M., Shea M. L., Heyder E., Knight D. R., 1982. Improved methods for cyanide and thiocyanate measurements. Naval Submarine Research Laboratory Report 976, Groton, Connecticut.
18. Divrikli U., Horzum N., Soylak M., and Elci L. 2006. Trace heavy metal contents of some spices and herbal plants from Western Anatolia, Turkey. *International Journal of Food Science & Technology, Oxford*. v. 41, n. 6, p. 712-716, http://dx.doi. org/10.1111/j.1365-2621.2005.01140.x.
19. Eikelboom D. H., Draaijer A., 1999. Activated sludge information system (ASIS). Available from http://www.asissludge.com. Accessed 09/11/2007.
20. EPA, 1996. U.S. Environmental Protection Agency, American Society of Civil Engineers, and American Water Works Association. Technology Transfer Handbook: Management of Water Treatment Plan Residuals. EPA/625/R-95/008. Washington DC.
21. EPA, 1993. Environmental Protection Agency. Constructed wetlands for wastewater treatment and wildlife habitat. Available from http://www.epa.gov/owow/wetlands/construct. Accessed 14/01/2008
22. Galceran M. T., Rubio R., Rauret G., 1990. Assessment of groundwater contamination subsequent to an environmental release. Waste Management 10:261-268.
23. Gerren R.A., Groswald D. E., Luttges M.W., 1976. Triethyltin toxicity as a model for degenerative disorders. *Pharmacology Biochemistry and Behavior.* 5: 299-307.
24. Ghafoor A., 2004. Metal ion in city waste effluent: Effect of application on soils and vegetables. Final technical Report of the ARF project funded by Pakistan Agricultural Research Council, Islamabad.
25. Ghafoor A., Rauf A., Arif M., Muzaffar W., 1995. Chemical composition of effluent from different industries of the Faisalabad city. *Pakistan Journal of Agricultural Sciences*. 31, 37-69.
26. Graham D.I., DeJezus E. V., Pleasure D. E., Gonatas, N. K, 1976. Triethyltin sulfate-induced neuropathy in rats. *Archives of Neurology.* 33: 40-48.
27. Haidar A., 2005. Environmental impact to use wastewater in agricultural irrigation (Ibb, Sana'a, Thammar). Dar Al-Kutub Ministry of Culture-Sana'a 397, 1110.
28. Haruvy N. (2006) 'Reuse of wastewater in agriculture – economic assessment of treatment and supply alternatives as affecting aquifer pollution', in Morel, B. and Linkov, I. (Eds.): Environmental Security and Environmental Management: The Role of Risk Assessment, Amsterdam, *Springer*, pp.257–263.
29. Heinemann G., Braun, S., Overbeck, M., Page, M., Michel, J. and Vogt, W. 2000. The effect of vanadium-contaminated commercially available albumin solutions on renal tubular function. *Clinical Nephrology*. 53(6), 473-478.
30. Hydrosult I., 2003. Consultants, experts-Coselis Wastewater and Sewage Sludge Reuse Feasibility Study, Sana'a Basin-Yemen
31. ICARDA, 2003. Analysis for soil and plant guideline Italconsult (1973) Water supply for Sana'a and Hodeida: Sana'a basin groundwater studies, vols 1 and 2. Italconsult and UNDP, Sana'a and Rome
32. Janos P., Vávrová J., Herzogová L., and Pilařová V., Effects of inorganic and organic amendments on the mobility (leachability) of heavy metals in contaminated soil: A sequential extraction study, Geoderma, 159, 335–341 (2010).
33. Jolly, Y. N., Islam, A., and Akbar, S.: Transfer of metals from soil to vegetables and possible health risk assessment, *Springer Plus*. 2, 1–8, 2013.
34. Kabata H. and Pendias A., 1993. Trace Elements in Soil and Plants, 2nd Edn., Boca Boca Raton FL, USA, 365, Lewis.
35. Kamal Abbas Merghem & Abdelhakim Jilali & Anass Ali Alnedhary & Hassan El Halouani & Khadija Dssouli, 2016. Impact of wastewater on groundwater resources in Sana'a basin, Yemen. *Arab J Geosci.* 9: 268.
36. Kumar Sharma R., Agrawal M., Marshall F., 2007. Heavy metal contamination of soil and vegetables in suburban areas of Vanasi, India. *Ecotoxicology and Environmental Safety*. 66: 258–266.
37. Kunz, Daniel, O. Nagappan, J. Silva-Avalos, and G. T. Delong, 1992. Utilization of cyanide as a nitrogenous substrate by Pseudomonas luorescens NCIMB 11764:

evidence for multiple pathways of metabolic conversion. Applied and Environmental Microbiology. 58: 2022-2029.

38. Levine A., Sanot A., 2004. Recovering sustainable water from wastewater. *Environ sci. Technol*.201A.
39. Luo M., Wang T., Lu Y., Giesy J.P., Shi Y., Zheng Y., Xing Y., and Wu G., 2007. Landscape ecology of the Guanting Reservoir, Beijing, China: Multivariate and geostatistical analyses of metals in soils, *Environ. Poll*. 146, 567-576.
40. Malla R., Tanaka Y., Mori K., Totawat K. L., 2007. Short term effect of sewage irrigation on chemical buildup in soil and vegetables. *The Agricultural Engineering*. *International CIGR EjournalManuscript.*9, 14.
41. Martin T. H., 1992. Chasing those elusive cyanide ions. Plating and Surface Finishing, 23-26.
42. McCasland M., Trautmann N., Porter K., Wagenet R., 2008. Nitrate: Health effects in drinking water. Available from http://pmep.cee.comell.edu/facts.slides–self/facts/nit-heefgrw85. html. Accessed 05/04/2008.
43. Ministry of Agriculture and Irrigation, 2012. A promising sector for diversified economy in Yemen: National Agriculture SectorStrategy 2012–2016, March.
44. Muchuweti M., Birkett, J.W., Chinyanga, E., Zvauya, R., Scrimshaw, M.D., Lester, J.N., 2006. Heavy metal content of vegetables irrigated with mixture of wastewater and sewage sludge in Zimbabwe: implications for human health. Agriculture. Ecosystem and Environment 112, 41e48.
45. Mujeriego R., Sala L., 1991. Golf course irrigation with reclaimed wastewater. *Water Sci. Tech*. 24 (9).
46. NAS/NRC, National Academy of Sciences/National Research Council, 1999. Arsenic in drinking water. Washington, DC. pp. 251-257.
47. Naseem R., Tahir, S.S., 2001. Removal of Pb(II) from aqueous solution by using bentonite as an adsorbent. *Water Res*. 35, 3982e3986.
48. NWRA, National WaterResources Authority, 2007. The study of the water resources management and rural water supply improvement in the Rebublic of Yemen, water resources management action plan for Sanaa Basin, Final Report, November
49. Odoh Rapheal and Kolawole Sunday Adebayo; Assessment of trace heavy metal contaminations of some selected vegetables irrigated with water from River Benue within Makurdi Metropolis, Benue State Nigeria, *journal of Advances in Applied Science Research*. vol. 2, 2011, Pelagia Research Library.
50. Oyaro N., Juddy O., Murago E.N.M., Gitonga E., 2007. The contents of Pb, Cu, Zn and Cd in meat in Nairobi, Kenya. *Int. J. Food Agric. Environ*. 5, 119e121.
51. PACER, 2006. Studies & design the reuse of wastewater from Sana'a Wastewater Treatment Plant.
52. Pichtel J. R., Gierke T. L and Scheidler D. A., 1994. Determination of Cyanide in Soils and Wastes by Ion Chromatography. An Honors Thesis (HONORS 499). Department of Natural Resources and Environmental Management, Ball State University, Muncie, IN 47306
53. Sharma R. K., Agrawal M., Marshall F., 2006. Heavy Metal Contamination in Vegetables Grown in Wastewater Irrigated Areas of Varanasi, India. Bull. Environ. *Contam. Toxicol*. 77:312–318. Springer Science+Business Media, Inc.
54. Snoeij N.I., Penninks A. H., Seinen W., 1987. Biological activity of organotin compounds-An overview. *Environmental Research.* 44: 335-353.
55. Tosukhowong P., Tungsanga, K., Eiam-Ong, S. and Sitprija, V., 1999. Environmental distal renal tubular acidosis in Thailand: an enigma. *American Journal of Kidney Diseases*. 33(6), 1180-1186.
56. USEPA, 2007. Water quality standards. http://www.epa.gov/watersciences/standards/UN 2012 Status and new developments on the use of brackish water for agricultural production in the Near East. Yemen Country Report. Prepared by: Eng. Abdulkarim Al-Sabri Edited by: Dr. Mary K. Halim. United Nations, Cairo, Egypt, November 2012.
57. UN, 2003. Economic and social commission for Western Asia wastewater treatment technologies: A General Review. United Nations, Distr. General E/ESCWA/SDPD.
58. US, DHHS (US Department and Health and Human Services), 1978. Available from http://www. Osha. gov/dts/s1tc/methods./toc.hml.
59. WHO, World Health Organization , 2005. Tin and inorganic tin compounds. Concise International Chemical Assessment Document 65. ISBN 92 4 1530650.
60. WHO, World Health Organization, 2006. Guidelines for the safe use of wastewater, excreta and grey water. Volume 1, policy and regulatory aspects.
61. WHO, World Health Organization, 2004. Inorganic Tin in drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality.
62. WHO, Word Health Organization, 1998. Boron: 8.1.1. Short-term toxicity and poisoning incidents. Environmental health criteria 204: Geneva, Switzerland: World Health Organization, [Online] Available: http://www.inchem.org/documents/ehc/ehc/ehc204.htm [Accessed: 3 May. 2010].
63. WHO, World Health Organization, 1980. Tin and organotin compounds — a preliminary review. Geneva, World Health Organization (Environmental Health Criteria No. 15.

